

REMARKS

I. INTRODUCTION

In response to the Office Action dated July 30, 2003, claim 3 has been amended and claims 4-10, 13-16 and 20-29 have been cancelled. Claims 1-3, 11, 12 and 17-19 remain in the application. Entry of these amendments, and re-consideration of the application, as amended, is requested.

II. CLAIM AMENDMENTS

Applicants' attorney has made amendments to the claim 3 as indicated above. This amendment was made consistent with the Office Action's suggestion solely for the purpose of clarifying the language of the claim as discussed below and was not required to distinguish the claims over the prior art.

III. DRAWING OBJECTIONS

On page (3) the Office Action objects to the drawings as failing to comply with 37 CFR 1.84(p)(5) because numerous reference sign(s) are not mentioned in the description, L_B and Λ for example.

In response, Applicants' attorney has amended the specification as indicated above to appropriately add the omitted reference signs. In addition, Applicants' attorney has amended FIGS. 4 and 6 to include reference numerals as shown on the marked up drawings included herewith that have been added to the specification (paragraphs beginning at page 8, lines 8 and 16). No new matter is involved.

In addition, the previously submitted proposed drawing changes to FIGS. 1, 2 and 3 as well as new FIG. 9 are also resubmitted as the current objections to the drawings in the Office Action have been corrected by amendments to the specification.

New replacement formal drawings of FIGS. 1, 2, 3, 4, 6 and 9 including the changes are also submitted.

IV. SPECIFICATION OBJECTIONS

On page (3) the Office Action objects to the specification as failing to provide proper antecedent basis for the claimed subject matter. The Office Action identifies that there is no

antecedent basis for many of the limitations in claims 1, 2, 3 and 17 including “a sampled grating including a plurality of sampled grating portions comprising a first phase separated from each other by portions with no grating”, “the second phase is substantially opposite that of said first phase” and “configured to maximize a coupling constant (κ) substantially evenly”.

In response, Applicants’ attorney has amended the specification as indicated above to appropriately add antecedent basis for the limitations of claims 1, 2 and 17 and claim 3 as amended. No new matter is involved.

V. CLAIM OBJECTIONS

On page (3) of the Office Action, claims 1, 2 and 17 are objected to because of certain informalities.

Respecting claim 1, the Office Action asserts that the limitation, “at the beginning of”, in claim 1 is unclear whether the first grating [burst] portion is part of or spaced apart from the first grating portion.

In response, Applicants respectfully traverse the objection. Claim 1 defines a plurality of sampled grating portions and a first grating burst portion as distinct elements. The first grating burst portion is “at the beginning of” a first sampled grating portion of the sampled grating. Whether or not the first grating burst portion is “spaced apart” from the first sampled grating portion is an issue of claim breadth not a lack of clarity; the relative relationship between the elements is clear. Note, for example, that dependent claim 3 further defines the relationship between the first grating burst portion and the first sampled grating portion as being “spaced apart”. Withdrawal of the objection is respectfully requested.

Respecting claims 1, 2 and 17, the Office Action also asserts that it is unclear how a grating can comprise a phase. Respecting claim 2, the Office Action further asserts that it is unclear what is meant by a phase being opposite another phase.

In response, Applicants respectfully traverse the objection. Applicants submit that the specification as filed teaches the concepts of a grating comprising a phase as well as a grating having a phase opposite of the phase of another grating. For example, the specification as filed teaches the following.

In the case of the SG-DBR to be produced with a phase mask, the sampling function can only take the value of 0,1 or -1, with -1 indicating a phase reversal of the grating function. (page 8, lines 1-2 of the application as filed) Emphasis added.

The phase mask technology for printing gratings, allows the sampling function to take on a value of +1, 0 and -1, with a manufacturable process that can be used to create sampled grating. Phase masking is well known to those skilled in the art, although this application is new. (page 8, lines 3-7 of the application as filed)

Another sampling function is shown in Figure 6. Reversing the phase of the grating at the beginning and end of each sample can be used to tailor the peak envelope to allow for higher kappa over a larger range. (page 8, lines 16-18 of the application as filed) Emphasis added.

Thus, Applicants submit that the terms of the claims including a grating phase are clear because they are taught in the specification and known in the art. Withdrawal of the objection is respectfully requested.

VI. NON-ART REJECTIONS

On page (4) of the Office Action, claims 1-3, 11, 12, and 17-19 were rejected under 35 U.S.C. §112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Respecting claim 1, the Office Action asserts that the limitation “a sampled grating including a plurality of sampled grating portions comprising a first phase separated from each other by portions with no grating” renders the claim indefinite. The Office Action asserts that it is unclear how a portion of a grating can have no grating.

In response, Applicants respectfully traverse the rejection. Applicants submit that the term “sampled grating” is known in the art to include portions with no grating. For example, Coldren et al., “Diode Lasers and Photonic Integrated Circuits”, John-Wiley and Sons, 1995, p. 351, lines 11-12, submitted herewith, teaches “the simplest form of modulated grating is the sampled grating in which a uniform grating is periodically blanked”. See also FIG. 8.8, Ibid. Thus, a sampled grating is known in the art to include portions with no grating. Accordingly, Applicants request withdrawal of the rejection.

Respecting claim 3, the Office Action asserts that the limitation “maximize a coupling constant substantially evenly across a selected tuning range” renders the claim indefinite. The Office

Action questions whether the Applicants intend to claim that the maximum values for the coupling constant are uniform across a tuning range.

In response, Applicants have amended claim 3 to recite that “maximum values for a coupling constant (κ) are substantially uniform across a selected tuning range”, consistent with the suggestion of the Office Action.

Respecting claim 17, the Office Action asserts that it is unclear how a sampled grating portion can have a first phase and a second phase.

In response, Applicants respectfully traverse the rejection. As discussed above, Applicants submit that the specification as filed and the art teach the concept of grating phase. In addition, an exemplary sampled grating portion having a first and second phase is shown in FIG. 6 of the application as filed. FIG. 6 shows a sampled grating portion having a first phase for a middle length L_{B+} and a second phase for each end length L_{B-} . Applicants respectfully request withdrawal of the rejection.

Respecting claim 19, the Office Action asserts that it is unclear what is meant by the limitation “reverse phase”.

In response, Applicants respectfully traverse the rejection. As discussed above, page 8, lines 1-2 of the application as filed teaches “the sampling function can only take the value of 0,1 or -1, with -1 indicating a phase reversal of the grating function”. Further as discussed above, and referencing FIG. 6, page 8, lines 16-18 of the application as filed teaches “reversing the phase of the grating at the beginning and end of each sample can be used to tailor the peak envelope to allow for higher kappa over a larger range”. Thus, Applicants respectfully submit that the limitation “reverse phase” is clear as supported by the specification. Withdrawal of the rejection is respectfully requested.

VII. PRIOR ART REJECTIONS

On page (5) of the Office Action, claims 1, 2, 3, 12, and 17 were rejected under 35 U.S.C. §102(b) as being anticipated by Huang, U.S. Patent No. 6,330,268 (Huang ‘268). On page (6) of the Office Action, claims 1, 2, 3, 12, and 17 were rejected under 35 U.S.C. §102(b) as being anticipated by Huang, U.S. Patent No. 5,715,271 (Huang ‘271). However, on page (7) the Office Action indicates that claims 11 and 18 would be allowable if rewritten to overcome the rejection(s) under 35

USC §112, second paragraph, and to include all the limitations of the base claim and any intervening claims.

In response, Applicants thank the Examiner for the indication of allowable subject matter, but respectfully traverse these rejections.

Independent claims 1 and 17 are generally directed to an invention that provides a distributed Bragg reflector such as can be used in a tunable laser. In one embodiment, as claimed in claim 1, a distributed Bragg reflector comprises a sampled grating including a plurality of sampled grating portions comprising a first phase separated from each other by portions with no grating and a first grating burst portion at the beginning of a first sampled grating portion of the sampled grating and comprising a second phase, said second phase being different from the first phase. In another embodiment, as claimed in claim 17, a distributed Bragg reflector comprises a sampled grating including a plurality of sampled grating portions separated from each other by portions with no grating. The sampled grating portions each have a first phase and a second phase. Neither of the cited references teach nor suggest these various elements of Applicants' independent claims.

Huang '268 describes a distributed feedback semiconductor laser (DFB laser) in which light feedback is performed by using a diffraction grating, and in which influence of external feedback noises can be decreased to suppress fluctuation of an optical output. The DFB laser comprises a diffraction grating structure portion which constitutes a resonator and which is divided into a plurality of regions along the longitudinal direction of the resonator, and one or more phase shift portions each disposed between adjacent regions of the diffraction grating structure portion, wherein total phase shift obtained by all of the phase shift portions has a quantity corresponding to λ/n , where λ is an oscillation wavelength, and n is an integer larger than 4 ($n > 4$). The total phase shift may have a quantity corresponding to a value within a range between $\lambda/5$ and $\lambda/8$.

However, Huang '268 lacks any discussion about a sampled grating including a plurality of sampled grating portions comprising a first phase separated from each other by portions with no grating as claimed in both independent claims 1 and 17. The Office Action asserts that the grating regions 66, 68 and 70 are a plurality of sampled grating portions comprising a first phase. However, these grating regions 66, 68 and 70 are not sampled grating portions, rather they are each regions of continuous gratings. Particularly, although the phase shift portion 74 between regions 66, 68 may read on a "portion with no grating", the plurality of the regions 66, 68, 70 does not comprise a first

phase (as with the plurality of sampled grating portions claimed) because the intervening phase shift portions 74, 76 taught by Huang '268 introduces a phase difference between the continuous gratings of the regions. Thus, Huang '268 teaches away from Applicants' invention because it describes grating structures comprising continuous grating regions that are each separated by one or more phase shift portions and do NOT have a first phase as the sampled grating portions of a sampled grating.

Thus, Applicants submit that the present §102 rejection in view of Huang '268 is overcome because each and every element of the claimed invention is not taught in the cited reference. Huang '268 does not teach or suggest a sampled grating including a plurality of sampled grating portions comprising a first phase separated from each other by portions with no grating as claimed in both independent claims 1 and 17. Withdrawal of the rejection is respectfully requested.

Huang '271 discloses and analyzes a polarization independent optical resonator comprising a phase-shifted grating structure. An application as a polarization independent optical wavelength filter with ultra-narrow bandwidth and fine tunability is described. Huang '271 teaches a resonator comprising first and second sections of phase shifted gratings, each of which comprises a plurality of grating sections of length L_g with a grating period of Λ_g and intervening phase shift sections of length L_s . Another phase shift section of length L_p is disposed between the first and second sections of phase shifted gratings. Col. 5, lines 26-35.

Although Huang '271 does appear to use sampled gratings, Huang '271 lacks any discussion about both a first burst portion as claimed in claim 1 and sampled grating portions wherein sampled grating portions each have a first phase and a second phase as claimed in claim 17.

Respecting claim 1, the Office Action asserts that the leftmost grating section of FIG. 1 of Huang '271 is a first grating burst portion. However, the leftmost grating section of FIG. 1 is indistinguishable from the remaining grating sections of the left sampled grating; the left sampled grating is defined by three parameters L_g , L_s and Λ_g which establish the repeating pattern of a sampled grating. Thus, the leftmost sampled grating section of FIG. 1 has the same phase as the remaining grating sections of the left sampled grating. However, claim 1 recites that the second phase of the first grating burst portion is different from the first phase of the plurality of sampled grating portions. Accordingly, Huang '271 does not teach or suggest a first grating burst portion as presently claimed in claim 1.

Respecting claim 17, the Office Action also asserts that Huang '271 discloses sampled grating portions wherein sampled grating portions each have a first phase and a second phase. However, each of the sampled grating portions of both the left and the right sampled gratings of FIG. 1 are homogenous in phase. Nowhere does Huang '271 teach or suggest a sampled grating where each sampled grating portion has two phases.

Thus, Applicants submit that the present §102 rejection in view of Huang '271 is overcome because each and every element of the claimed invention is not taught in the cited reference. Huang '271 does not teach or suggest a first grating burst portion at the beginning of a first sampled grating portion of a sampled grating and comprising a second phase as claimed in claim 1. In addition, Huang does not teach or suggest sampled grating portions wherein each sampled grating portion has a first phase and a second phase as claimed in claim 17. Withdrawal of the rejection is respectfully requested.

The various elements of Applicants' claimed invention together provide operational advantages over the systems disclosed in Huang '268 and Huang '271 and solves problems not recognized by Huang '268 and Huang '271. For example, the present invention teaches embodiments of a sampled grating with a wider wavelength range and with a larger κ throughout than a conventional sampled grating.

Thus, Applicants submit that independent claims 1 and 17 are allowable over Huang '268 and Huang '271. Further, dependent claims 2-3, 11, 12, and 18-19 are submitted to be allowable over Huang '268 and Huang '271 in the same manner, because they are dependent on independent claims 1 and 17, respectively, and because they contain all the limitations of the independent claims. In addition, dependent claims 2-3, 11, 12, and 18-19 recite additional novel elements not shown by Huang '268 and Huang '271.

VIII. CONCLUSION

In view of the above, it is submitted that this application is now in good order for allowance and such allowance is respectfully solicited. Should the Examiner believe minor matters still remain that can be resolved in a telephone interview, the Examiner is urged to call Applicants' undersigned attorney.

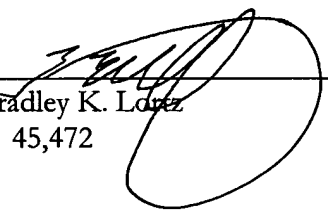
Respectfully submitted,

GATES & COOPER LLP
Attorneys for Applicants

Howard Hughes Center
6701 Center Drive West, Suite 1050
Los Angeles, California 90045
(310) 641-8797

Date: September 30, 2003

BKL/io

By: 
Name: Bradley K. Lopez
Reg. No.: 45,472

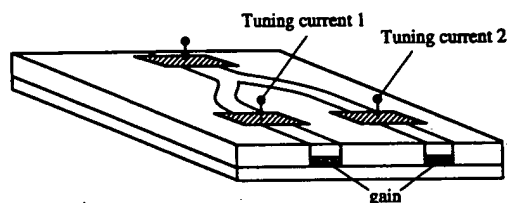
recombination in this example is inaccurate for currents > 1 mA. At 1 mA the carrier density, given by the square rooted bracket in Eq. (8.11), is $7 \times 10^{17} \text{ cm}^{-3}$. At this point Auger recombination accounts for about 17% of the total recombination (using $C = 3 \times 10^{-29} \text{ cm}^6/\text{s}$). Thus, we would actually need 1.2 mA at this point. At 8 mA, the Auger current would be about one-third of the total. Thus, we would actually need 12 mA of total current to get the desired carrier density.

8.2.3 Extended Tuning Range Four-Section DBR

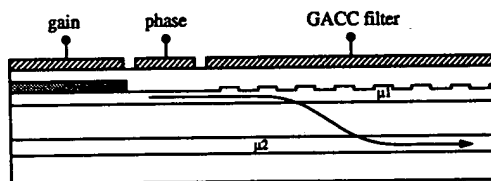
To obtain a wider tuning range than the 8–10 nm possible with the three-section DBR, research on other extended tuning range lasers has been carried out. Figure 8.6 gives some examples. One of these—the four-section modulated-grating DBR—builds upon the principles of the basic three-section DBR design.

As shown in Fig. 8.7 this modulated-grating device deviates from the three-section DBR only in that two separately contacted grating reflectors

• Coupled Y-cavity laser



• Grating-assisted co-directional coupler



• Sampled grating DBR laser

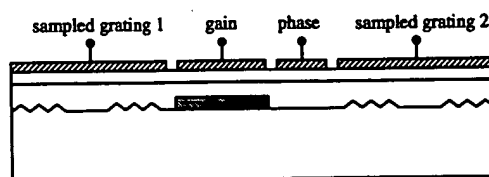


FIGURE 8.6 Examples of extended tuning range lasers. After [3–6].

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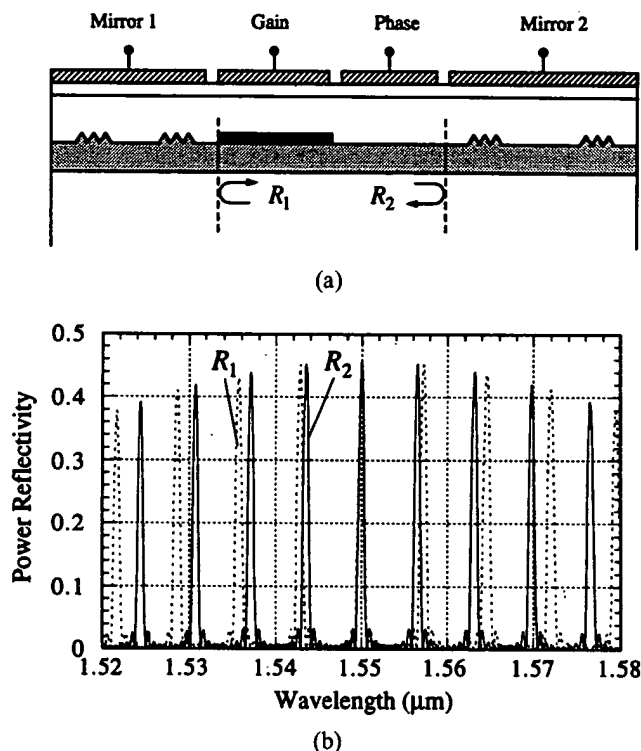


FIGURE 8.7 Four-section extended tuning range laser. (a) Device layout; (b) individual sampled-grating mirror reflectivities, R_1 and R_2 . Alignment at $1.55 \mu\text{m}$ is indicated, so that the net mirror loss will only have a single minimum at $1.55 \mu\text{m}$. A slight change in index of one mirror will shift the alignment position to another pair of peaks.

are used for the end mirrors, and each of these contains a periodic modulation of the amplitude or phase of the grating. This periodic spatial modulation, which can be as simple as a periodic blanking of the grating, creates a corresponding reflection spectrum with periodic maxima in the frequency domain. This can be understood most simply in the special case of weak reflections in a very long grating with very short grating bursts. Here the impulse response is seen to be a comb function, and the Fourier transform of a comb function is another comb function in the frequency domain. Figure 8.8 illustrates how the periodic blanking of a continuous grating results in a comb of reflection orders.

As suggested above, the simplest form of modulated grating is the sampled grating in which a uniform grating is periodically blanked, perhaps with a double exposure during the lithographic fabrication step. For a finite-length grating the reflection coefficient for each peak in the comb of reflection maxima has the same form as the unsampled grating, i.e., Eq. (6.37), however, in this

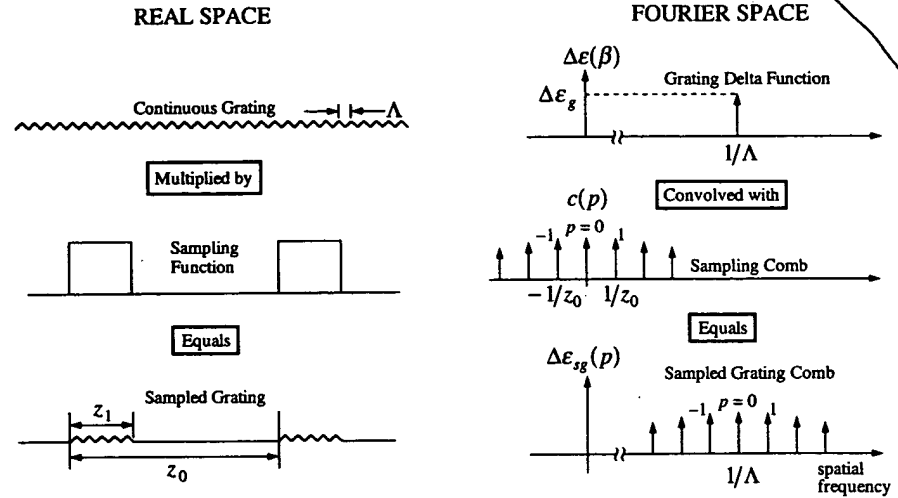


FIGURE 8.8 Sampling of a continuous grating is accomplished by multiplying it by a sampling function. In the Fourier domain the delta function spectrum of the continuous grating is replicated into a comb.

case the total reflection spectrum is composed of a superposition of these reflection components, one for each peak (reflection order) of the comb. Also, the coupling constant, κ_p , and the normalized propagation constant, σ_p , are functions of the duty factor of the sampling function, z_1/z_0 , and the peak (or order) number, p , in the comb of reflection peaks. For simple periodic blanking of a grating, the coupling constant is given by

$$\kappa_p = \kappa_g \frac{z_1}{z_0} \frac{\sin(\pi p z_1 / z_0)}{(\pi p z_1 / z_0)} e^{-j\pi p z_1 / z_0}, \quad (8.12)$$

where κ_g is the coupling constant for the continuous, unsampled grating, z_1 is the length of the grating burst, and z_0 is the sampling period. From Eq. (6.37) the reflection coefficient for one of the reflection orders is,

$$r_p = \frac{-j\kappa_p^* \tanh[\sigma_p L_g]}{\sigma_p + j\delta_p \tanh[\sigma_p L_g]}, \quad (8.13)$$

where

$$\sigma_p = \sqrt{|\kappa_p|^2 - \delta_p^2},$$

$$\delta_p = \frac{2\pi n}{\lambda} - j\frac{\alpha}{2} - \frac{\pi}{\Lambda} - \frac{\pi p}{z_0},$$

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$$r_g = \sum_p r_p. \quad (8.14)$$

In Eq. (8.14) we should only use the largest r_p at any wavelength in the summation to be consistent with the assumptions of the coupled-mode formalism which only considers one Fourier order at a time.

As indicated in Fig. 8.7, the 4-section sampled-grating DBR laser makes use of two different sampled-grating mirrors. By sampling the gratings at different periods, reflection maxima with different wavelength periods are created in each mirror. Thus, as shown in part (b), if a certain reflection maximum from one mirror is aligned with one in the second mirror, the others will be misaligned, and the product of the two reflectivities which determines the cavity loss, will only have one maximum. That is, the laser will still be a good single-frequency laser with very good MSR. Now, if both mirrors are tuned together, e.g., by connecting their electrodes, we are left with an effective three-section DBR that functions identically to the normal three-section DBR. Thus, ~ 8 nm of continuous single-mode tunability might be expected at $1.55 \mu\text{m}$ by simultaneous tuning of the phase electrode.

However, if the index of one grating is tuned differently from the other, adjacent maxima will successively line up. We refer to this differential adjustment to obtain alignment of different reflection maxima as *channel changing*, whereas the above joint adjustment of the two mirrors is *fine tuning*. If we wish to have full wavelength coverage, the channel spacing between mirror reflection maxima should be less than the fine-tuning range of ~ 8 nm. Since the periodicities of the maximas may be only slightly different, only a relatively small differential index change is necessary to switch channels. Thus, with a differential effective index change of less than $\sim 0.1\%$, it is possible to switch the alignment point across many different reflection maxima channels. As can be seen, this sliding-scale action is very similar to the function of a vernier scale. Figure 8.9 gives experimental results from ridge-waveguide sampled-grating devices near $1.5 \mu\text{m}$. As can be seen a large tuning range with very good side mode suppression is possible.

8.2.4 Laser-Modulator or Amplifier

One of the more important PICs being developed in recent years is the laser-modulator. Usually the laser is also a tunable laser, so as shown in Fig. 8.10, we again have at least three waveguide sections butted together. In this case, however, one of the sections (the modulator) is outside of the laser cavity beyond the DBR mirror. The modulator section is somewhat analogous to the phase-shift section in the continuously tunable laser. However, here we desire an intensity modulator rather than a phase modulator, so that the laser can operate cw and the emitted lightwave can be modulated external to the cavity.